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ORIGINAL ARTICLE

The impacts of dust size distribution on the head-on collision of quantum dust-acoustic solitary waves in ultradense astrophysical objects

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Abstract The head-on collision between two quantum dust-acoustic solitary waves (QDASWs) in ultradense astrophysical objects has been investigated theoretically using the extended Poincaré-Lighthill-Kuo (PLK) method. The Korteweg-de Vries equations and the analytical phase shifts after the head-on collision of the two QDASWs in quantum dusty plasmas are obtained. Numerically, the obtained results demonstrate that the dust size distribution, the quantum corrections of diffraction and the temperatures of electrons and ions have strong effects on the nature of the phase shifts and the trajectories of the two QDASWs after collision.

Keywords Head-on collision · Quantum dust-acoustic solitary waves · The extended Poincaré-Lighthill-Kuo · Ultradense astrophysical objects · The dust size distribution

1 Introduction

Recently, there have been several motivations for studying different types of collective processes in a dusty plasma (plasma with charged extra component of micron- or submicron-sized dust grains, electrons and ions) due to their relevance to many space plasma (Mendis and Rosenberg 1994; Horànyi 1996; Mendis 2002; El-Labany et al. 2008, 2009a; Rahman et al. 2008; Shalaby et al. 2010), as well as in the laboratory (Barkan et al. 1994, 1996). It should be mentioned here that, one of the most famous and important dusty plasma wave modes is the dust-acoustic solitary waves (DASWs), which were first presented through the theoretical model of Rao et al. (1990). The phase velocity of the DASWs is much smaller than the electron and ion thermal speeds. Accordingly, the inertialess electrons and ions establish equilibrium in the potential of the DASWs. Here the pressure gradient is balanced by the electric force, leading to the Boltzmann electron and ion number density. Therefore, the creation of DASWs is evaluated due to the restoring force, which comes from the pressures of the inertialess electrons and ions, while the dust mass provides the inertia (Shukla and Mamun 2002).

Currently, quantum plasma physics (i.e., plasma physics has a very high electron number density and a low electron temperature in comparison with classical plasmas where the plasma particle number density is relatively low and the plasma temperature is rather high) is a new emerging and a rapidly growing subfield of plasma physics. Quantum transport models have received great attention in recent years mainly due to their relevance for describing quantum effects in plasmas, in microelectronic devices (Markowich et al. 1990; Shpatakovskaya 2006; Ang et al. 2003) and understanding various properties of dense-high pressure plasmas, such as the white dwarfs and neutron stars (Jung 2001). It is well known that the quantum effect becomes important in plasmas, when the de Broglie wavelength (which is the spatial extension of the wave function due to quantum uncertainty principle) associated with the particles is comparable to the dimension of the system. On the other hand, for studying quantum plasma phenomena, it is im-

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